Conserving a urban habitat: Enhanced detection of common swift nests in buildings using a video fusion method.

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Abstract

Common swifts (*Apus apus*) nest in cavities and cracks in building facades and roofs. It is a declining species in Europe, partly due to the loss of suitable breeding habitat caused by urban building renovation (e.g. thermal insulation). In several countries, renovation projects must quantify the amount of habitat occupied by swifts that will be destructed, and provide compensatory measures, such as installing nest boxes in the renovated building. However, nesting swifts are uneasy to detect visually. We report a video method we used to improve swift nest detection. It is based on continuous filming of a building's facade (for 1-2 hours), and later video-frame fusion to reveal swift flying in and out of cavities in the facade. Based on a continuous dataset of swift passages during a full breeding season, we discuss favorable period in the season and day hours to efficiently detect nesting activity and assess building occupancy. We provide a software for other conservation projects that can use the same video-fusion method.

The common swift (*Apus apus*) is a declining species in France (population decline estimated at -46% between 2001 and 2019; Fontaine et al., 2020) and in other European countries (e.g. -38% between 1995 and 2010 in the UK; Balmer et al., 2013). This species has a *Near Threatened* status in France (IUCN France, 2016). Among the possible causes of decline, studies have focused on climate change and climate anomalies, both in Europe (Thomson et al., 1996; Rajchard et al., 2006) and in the wintering area of the common swift (Ambrosini et al., 2011; Boano et al., 2020), located in sub-Saharan Africa (Akesson et al., 2020). Furthermore, as these birds are aerial insectivores, the decline in the quantity of insects available (Goulson et al., 2015; Hallmann et al., 2017), due in particular to the use of pesticides, is also considered to be a direct cause of the species' decline (Moller et al., 2021). Lastly, as common swifts mainly nest in cavities and cracks in the facades and roofs of buildings, the gradual depletion of this urban habitat, due to the modernisation of buildings (e.g. renovation, waterproofing, external thermal insulation, demolition and new construction techniques) is a third cause of decline (Balmer et al., 2013; Genton & Jacquat, 2014; Crowe et al., 2010; Schaub et al., 2016; Dulisz et al., 2022).

When building demolition or renovation projects may impact this urban habitat, recommendations exist in several European countries for conserving or recreating habitat suitable for breeding swifts (e.g. Switzerland: Scholl, 2016; Ireland: Whelan et al., 2018; Italy: Gelati et al., 2019; France: LPO, 2024). In France, the destruction of common swift habitat is prohibited by law (as for any other protected species; Légifrance, 2025a,b), and can only be done after obtaining a derogation, which implies compensatory measures, in particular by installing nest boxes as part of the building project, and subsequent monitoring of nest box occupancy. Similar obligations exist in other countries, such as Germany and Poland (Schaub et al., 2016). The installed nest boxes can help keep common swift colonies in place, but it often takes several years for them to be occupied (Schaub et al., 2016; Dulisz et al., 2022).

The first step is to determine whether a building actually is a habitat occupied by swifts. An inventory of the number of cavities and cracks used on each façade of the building has to be carried out during one or more breeding seasons preceding renovation. This inventory is the basis on which the compensatory measures can be sized: in France, 2 to 3 nest boxes are usually required per active nesting cavity destroyed. The usual census method consists of visually observing the facade for at least 1 hour to detect swifts arriving or leaving their cavity (e.g. Schaub et al., 2016; Nobauer et al., 2018). In practice, this method requires a great deal of visual attention, as nesting swifts only pass through in a fraction of a second and are very discreet (contrary to non-breeding, screaming swifts). Even for experienced observers, this direct visual method is not infallible, particularly on large buildings where numerous cavities may be present. It is easy to confuse two neighbouring cavities if several passages occur at the same time, or if the observer's attention is not full and constant.

To overcome these difficulties, we developed a video method that increases the likelihood of detecting common swifts' nests. First, we film a facade continuously for 1 to 2 hours from a

fixed point. Second, to facilitate and accelerate the videos' analysis back in the lab, we merge the frames of the video by applying a *minimum* filter, that retains only the darkest value of each pixel over the chosen number of frames (i.e. the chosen duration). This *video fusion* process sums up the duration of the video in a single still image, where the swifts' passages appear clearly. This way, we obtain a record of all the birds passing through the wall during the recording session, with the precise locations of all the nesting cavities. (Fig. 1).

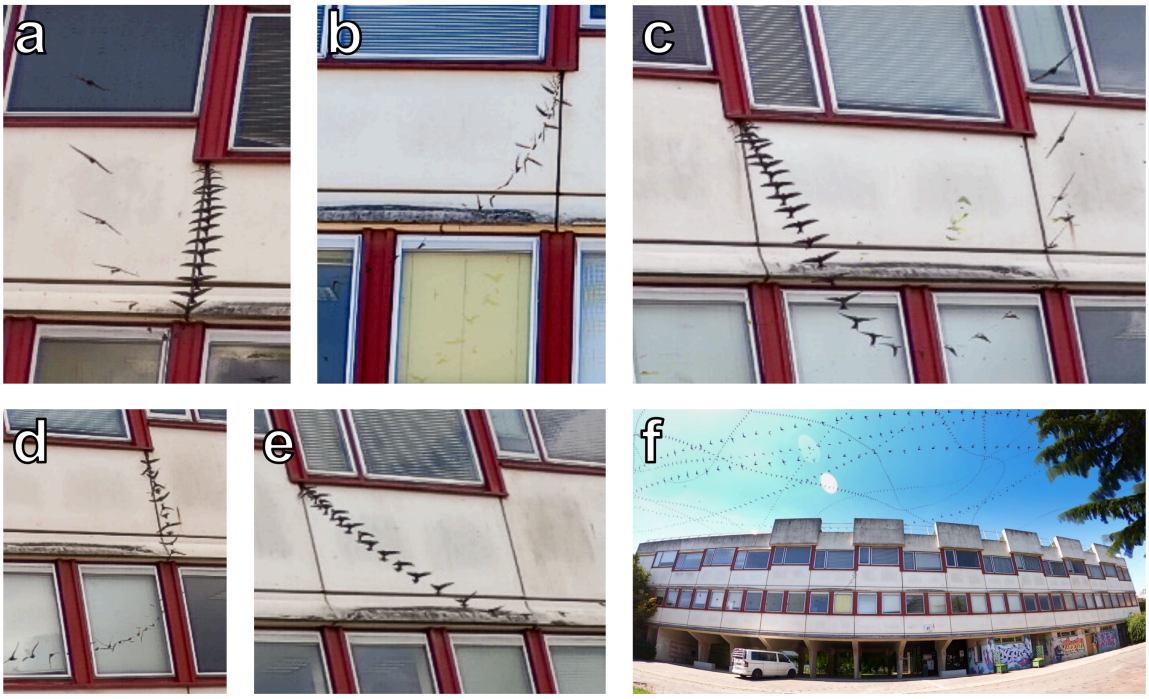

Figure 1 (a-e) Common swifts passing through cavities in the facade of a building **(f)**, filmed with a static wide angle camera. Video frames were merged to produce a still image, by applying a filter that retains the darkest value of each pixel over the video duration. As swifts are darker than the building, their flight trajectories to and from cavities are revealed and easily detectable. Note that gliding flight (a, c, e) indicates a swift entering the facade, whereas flapping flight (b, d) indicates a bird exiting the building.

The fusion filter can be formally written as follows:

(1) $$V_{x,y} = \min \left\{ v_{x,y,t} \right\}_{t=1}^{n}$$

with:

- $v_{x,y,t}$ the value of a pixel at position x (horizontally), y (vertically) and at time t in a video sequence (containing n frames).
- $V_{x,y}$ the value of a pixel at position x, y in the final merged still image.

This filter is applied to each channel of the video file (i.e. 3 channels for RGB videos).

As storing all frames of a video in memory to find the overall minimum value is unpractical, the filter can be applied recursively while playing the video file:

(2) $$V_{x,y} = \min\left\{v_{x,y,t}, V_{x,y}\right\}$$

In practice, merging a very long video sequence into a single image is not the best option, because too many birds (and possibly insects) passing through the frame decreases the readability of the image, and can make it difficult to see whether the bird has really entered a cavity in the facade (i.e. the bird trajectory must disappear at the cavity entrance). Hence we usually merge the video by one-minute segments, which for a 2-hour video produces 120 still images, which are quick enough to inspect, and hence assess facade occupancy.

The favourable period to detect common swifts' nests is when the adults perform regular roundtrips to feed the young (Arens, 2011a,b; Nobauer et al., 2018). In French Britanny, this usually corresponds to late June to mid July, but note that the period varies greatly depending on the latitude and year (Genton & Jacquat, 2014; Akesson et al., 2020). The usually recommended hours for visual observation are in the evening around sunset (Nobauer et al., 2018), but may also include the late morning (Schaub et al., 2016), where feeding visits are also frequent (Arens, 2011a,b). With the present video method, the efficiency of detection depends on the recording duration, as shown in Fig.2 : while a 1-hour video can be enough to detect a nest in the highest activity periods (i.e. late afternoons and evenings after hatching), a 2-hour video duration can provide an efficient detection throughout most of the day (10h-22h), for approximately 30 days after hatching.

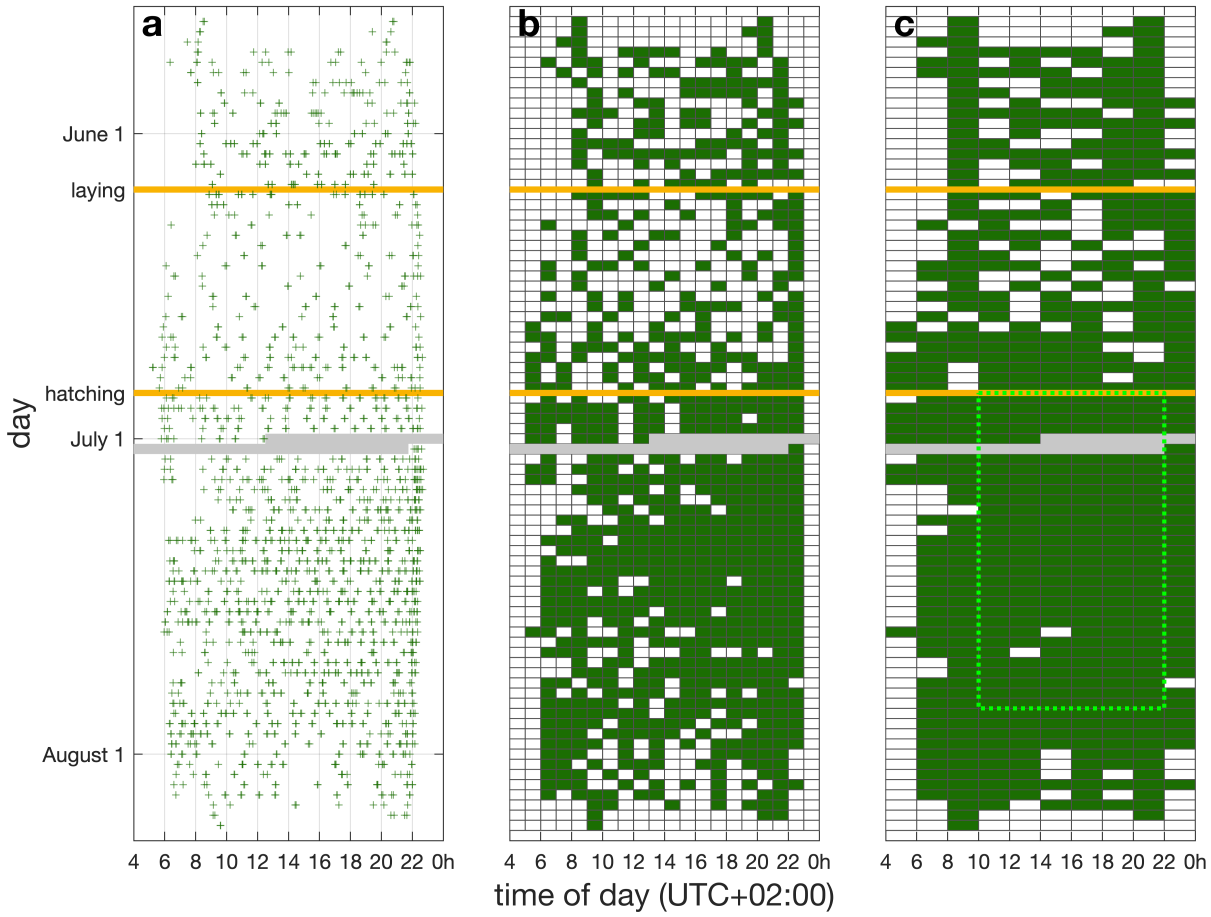

Figure 2 Example time distribution (days vertically downwards, hours horizontally) of passages performed by a couple of common swift adults flying in and out of their nest cavity. **(a)** Representation of each bird passage (green '+' dots) recorded using an IP camera placed inside a nest box in Rennes, France, from May to August 2024. Recording started on the first morning with both birds in the nest box (May 21). Two eggs were laid on June 7-8, and hatched on June 27-28. There was a network interruption on July 1-2, causing some data loss (grey area). Both adults and both juveniles left the nest box on August 7-8. Comparing the pre-laying period (May 21 – June 7), the incubation period (June 8 – 27) and the feeding period (June 27-August 8), the third period had the highest density of passages. **(b)** 1-hour time slots containing at least 1 passage are colored in green, while time slots containing no passage are left blank. Assuming an observer filming from outside the building for one hour continuously, the nest detection would have been most effective during the late afternoons and evenings (18-22h), as this period contains green slots almost enterily for approximately 20 days following hatching. **(c)** Following the same procedure with 2-hour time slots shows that doubling the video duration greatly improves passage recording probability: almost any 2-hour slot between 10h and 22h, for at least 30 days after hatching (green dotted perimeter) would have detected 1 passage (or more) in or out of the nest box.

Another benefit of the present method is that recorded images provide concrete evidence that birds inhabit a facade. Still images can easily be shared with the various parties involved in the building project, who may not have been able to see swifts entering the building for themselves.

We applied this video method to inventory common swift nests on two university campus renovation projects in Rennes, France. By filming each facade of these large campus buildings

for 2 hours, we were able to detect 78 active swift nests (de Margerie et al., 2023a,b), leading to the compensatory installation of 212 nest boxes from 2024 to 2027.

To allow this video detection method to be used on other conservation projects, we provide a free software for merging video frames (https://github.com/edemargerie/videoFusion), with a detailed user manual and technical guidelines on how to implement the method in the field.

Note that the same method can be used to detect other bird species nesting in cavities in walls or cliffs. In the case of a species appearing brighter than the background, one will only need to modify filter (1) by replacing the *min* function with a *max* function.

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